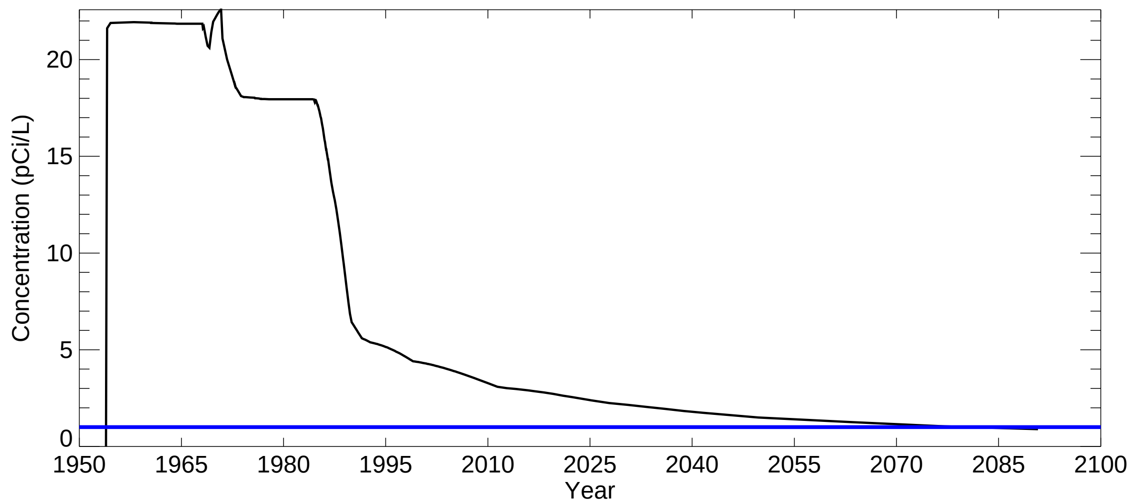

Figure A-9-13. I-129 peak aquifer concentrations (pCi/L) (SRPA MCL = blue line, model predicted = black line).

A-9.3.3 Np-237

The sources of Np-237 in the vadose zone, listed in order of decreasing magnitude, are (1) the OU 3-13 soil sites at 0.133 Ci, (2) CPP-3 injection well failure at 0.093 Ci, and (3) the tank farm sources at 0.027 Ci. The amount of Np-237 released directly into the aquifer from the injection well was 0.93 Ci.

A-9.3.3.1 Vadose Zone Np-237 Simulation Results

Figures A-9-14 and A-9-15 illustrate the horizontal and vertical distribution of vadose zone Np-237 in 1979, 2005, 2049, and 2095. Figure A-9-16 presents the peak vadose zone concentrations through time (excluding the tank farm submodel area), and Figure A-9-17 illustrates the Np-237 activity flux into the aquifer.

The simulated peak concentration (excluding the tank farm submodel area) was 6.00e+3 pCi/L in 1990 and corresponds to the near-surface soils at Sites 37A and 37B, which contributed a combined total of 0.0765 Ci. These sites were placed in the model in 1990 and may have been conservatively overestimated. The location of the CPP-37A and CPP-37B sites east of the tank farm and the neptunium K_d (2.0 mL/g) result in vadose zone concentrations persisting because of a lower infiltration rate in this area and retardation.

Site CPP-37B was sampled for Np-237 in fall 2005 during ongoing OU 3-13 Group-3 work. There were 11 samples taken and one duplicate. Nine samples and the duplicate were non-detect. Two samples were flagged J (an estimated quantity) and the soil concentration for these two samples was 0.3 +/- 0.1pCi/g. These results were received after the Np-237 modeling was completed for OU 3-14. Using the conservative OU 3-13 estimate in the model for this site resulted in a predicted future concentration that was always below MCLs. No attempt was made to decrease the Np-237 source term based on the new data or rerun the model, because the conservative estimate did not result in an unacceptable predicted future aquifer concentration.

A-9.3.3.2 Aquifer Np-237 Simulation Results

Figure A-9-18 illustrates the horizontal distribution in the aquifer Np-237 in 1979, 2005, 2049, and 2095. Figure A-9-19 presents the peak aquifer concentrations through time. The peak aquifer Np-237 concentration was 27.1 pCi/L in 1971 and originated from the CPP-3 injection well. Np-237 exceeded the Snake River Plain Aquifer MCL concentration from 1954 through 1987.

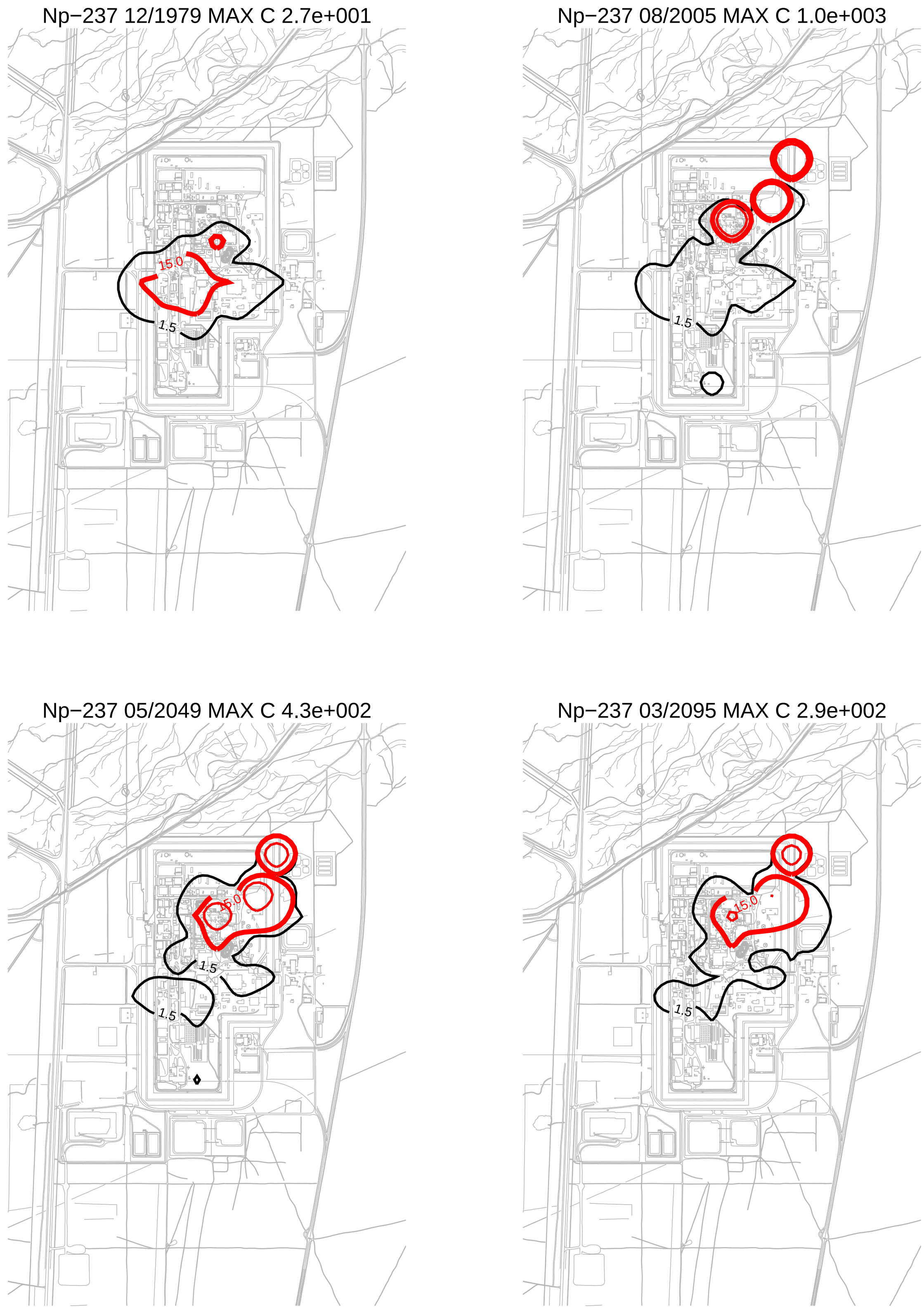

Figure A-9-14. Np-237 horizontal vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

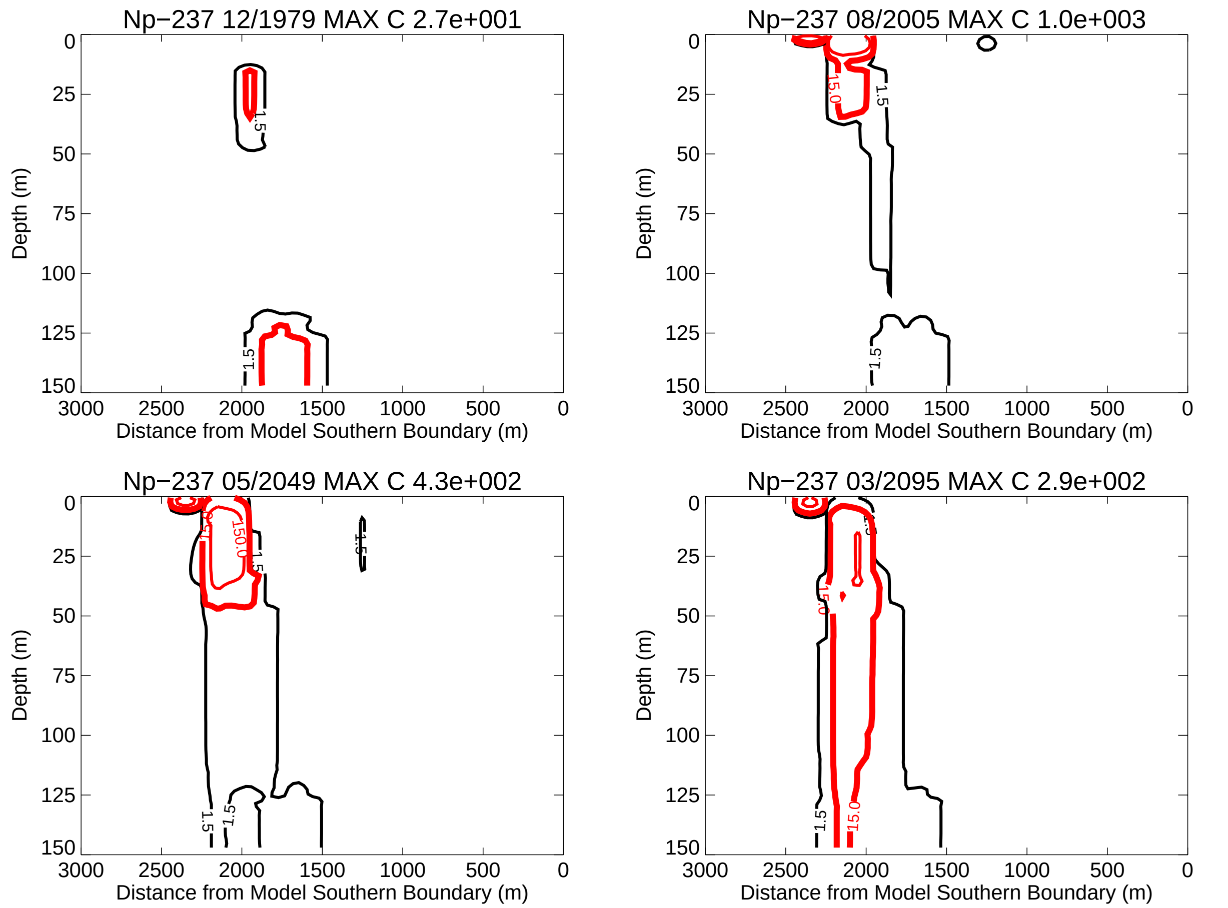

Figure A-9-15. Np-237 vertical vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

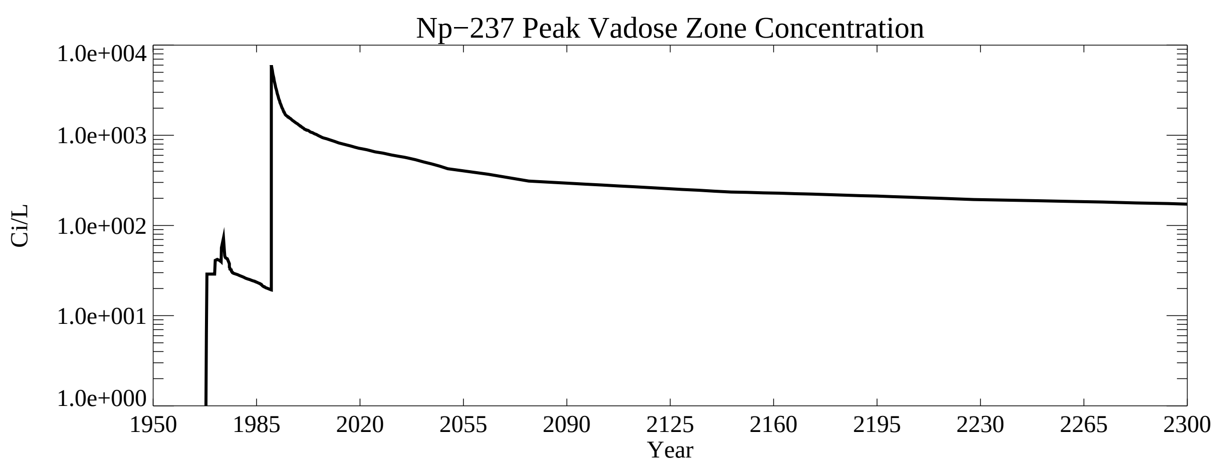

Figure A-9-16. Np-237 peak vadose zone concentrations excluding tank farm submodel area (pCi/L).

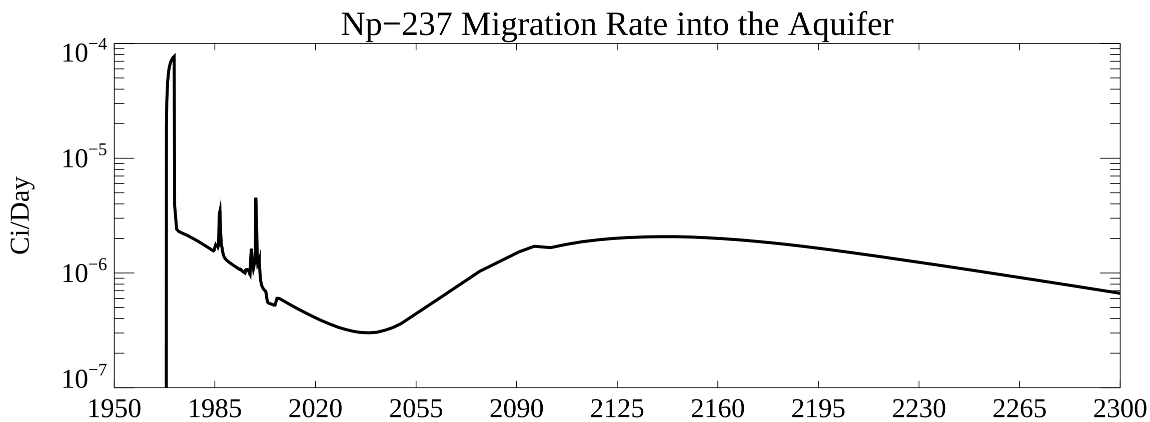

Figure A-9-17. Np-237 activity flux into the aquifer (Ci/day).

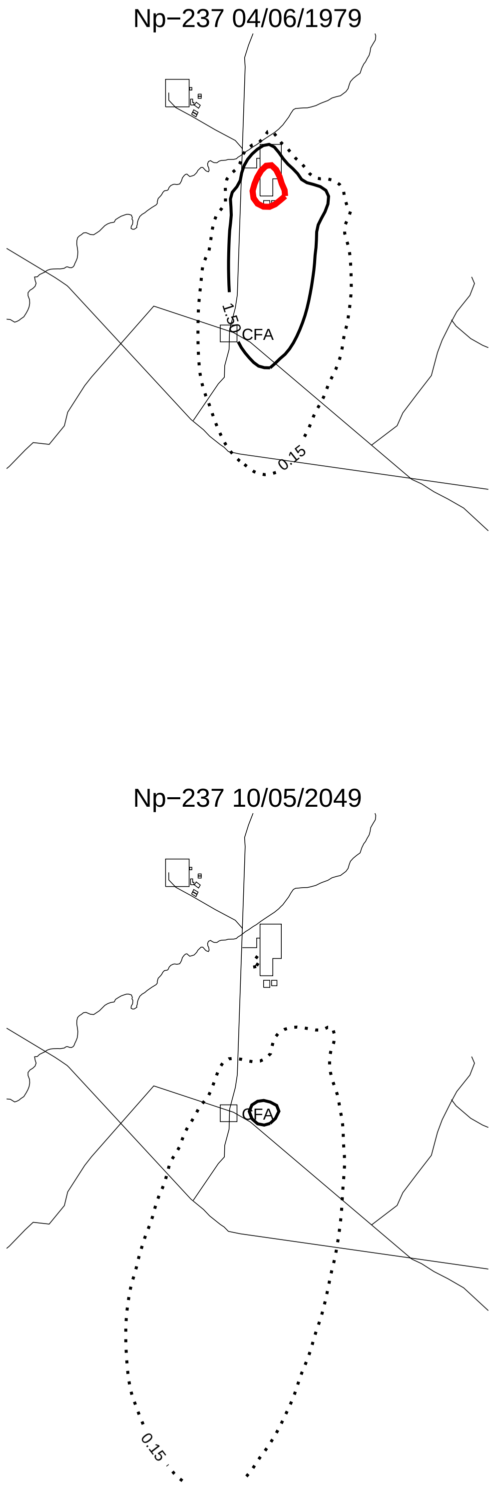

Figure A-9-18. Np-237 horizontal aquifer concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line, SRPA MCL/100 = thin black dashed line).

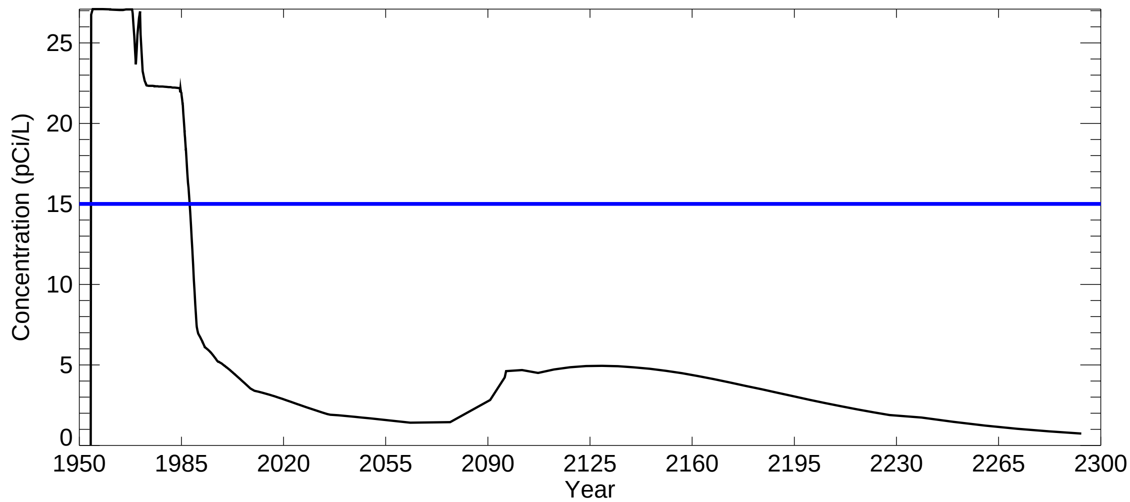

Figure A-9-19. Np-237 peak aquifer concentrations (pCi/L) (SRPA MCL = blue line, model predicted = black line).

A-9.3.4 Pu-239

The sources of Pu-239 in the vadose zone, listed in order of decreasing magnitude, are (1) the tank farm sources at 6.94 Ci, (2) the OU 3-13 soil sites at 1.05 Ci, (3) CPP-3 injection well failure at 0.011 Ci, and (4) the former percolation ponds at 0.0011 Ci. The amount of Pu-239 released directly to the aquifer from the injection well was 0.0124 Ci.

A-9.3.4.1 Vadose Zone Pu-239 Simulation Results

Figures A-9-20 and A-9-21 illustrate the horizontal and vertical distribution of the vadose zone Pu-239 at four time periods: 1979, 2005, 2049, and 2095. Figure A-9-22 presents the peak vadose zone concentrations through time (excluding the tank farm submodel area). Figure A-9-23 presents Pu-239 activity flux to the aquifer and illustrates only a small fraction of the tank farm Pu-239 reaches the aquifer because of the large retardation factor and radioactive decay.

The tank farm sources account for most of the Pu-239 released into the vadose zone. The peak simulated vadose zone concentration (excluding the tank farm submodel area) was 53.8 pCi/L in 1973 and corresponds to the CPP-31, and CPP-79 deep sites. The 1,000 (mL/g) K_d allows the Pu-239 to act as a nearly continuous leaching source during the simulation. This can be seen in the activity flux rate (Figure A-9-23).

A-9.3.4.2 Aquifer Pu-239 Simulation Results

The Pu-239 aquifer model was only run to evaluate effect of the injection well Pu-239 on aquifer water quality. Figures A-9-22 and A-9-23 indicate that the peak vadose zone concentrations will fall below the Snake River Plain Aquifer MCL before the peak Pu-239 arrives in the aquifer. The Tc-99 and Sr-90 simulations indicate an activity flux to the aquifer resulting from the tank farm sources of nearly 10^{-5} Ci/day is needed to bring aquifer concentrations near 10 pCi/L. The peak Pu-239 activity flux is always less than 10^{-8} Ci/day. The peak simulated aquifer concentration was 0.0334 pCi/L in 1960 and is the result of the CPP-3 injection well operation. Concentration contour plots are not provided because the Pu-239 concentrations were always predicted to be nearly two orders of magnitude lower than the Snake River Plain Aquifer MCL of 15 pCi/L during the simulation. Figure A-9-24 presents the peak aquifer concentrations resulting from the CPP-3 injection well through time averaged over a 15-m well screen.

The simulated Pu-239 occurring in the aquifer was only the result of direct injection into the CPP-3 disposal well, because the large interbed and alluvium plutonium K_d (1,000 mL/g) prevents significant amounts of Pu-239 originating from the tank farm sources from reaching the aquifer during the simulation period. The OU 3-14 groundwater pathway analysis did not predict an unacceptable aquifer risk from plutonium because it used a realistic plutonium K_d for the alluvium and interbed sediments (see Appendix D) and the isotope-specific half-life. This is in contrast to the OU 3-13 analysis, which predicted a groundwater risk, because it used the very conservative Track 2 guidance K_d of 22 mL/g (DOE-ID 1994) and used the longer Pu-241 half-life for all the plutonium isotopes. The better assessment results in more realistic risk analysis and leads to a conclusion of aquifer concentrations never exceeding the Snake River Plain Aquifer MCL.

The aquifer risk from a mobile fraction can be estimated from the Tc-99 simulation because both are be long-lived and mobile. Appendix D provides an estimate of 1 to 2.5% for the total mobile fraction in SDA sediment from column experiments. The Tc-99 simulation provided a maximum aquifer concentration of 10.8 pCi/L in 2095 from a total 4.78 Ci shallow vadose zone source (3.56 Ci from the tank farm, 1.13 Ci from the percolation ponds, 0.093 from the OU 3-13 sources). Using the upper bound for the mobile fraction (2.5%) and a total shallow vadose zone source of 9.18 Ci (8.01 Ci from the tank farm, 0.0017 Ci from the percolation ponds, 1.17 Ci from the OU 3-13 soils sites), the maximum aquifer concentration would be 0.52 pCi/L from 0.23 total mobile curies of plutonium. This is far below the 15 pCi/L Snake River Plain Aquifer MCL concentration.

Figure A-9-20. Pu-239 horizontal vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

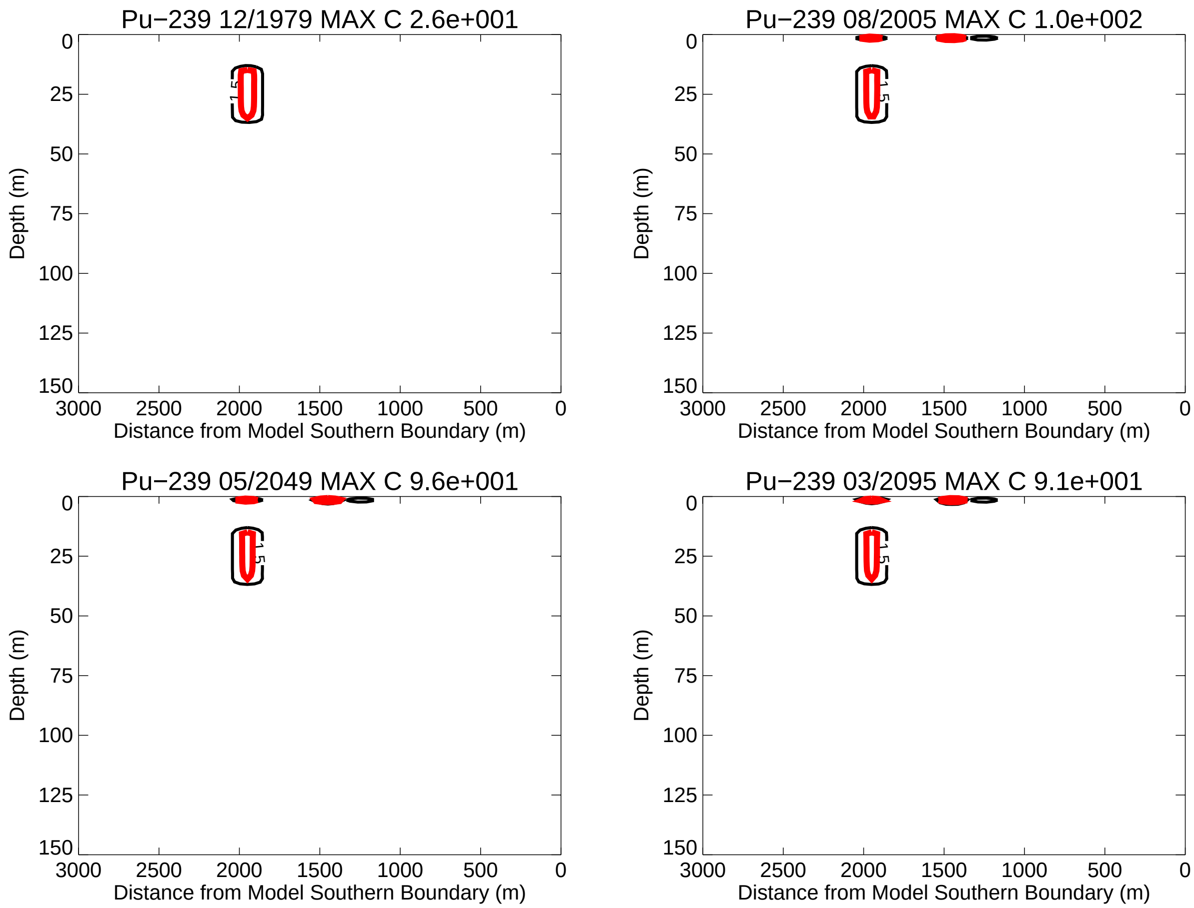

Figure A-9-21. Pu-239 vertical vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

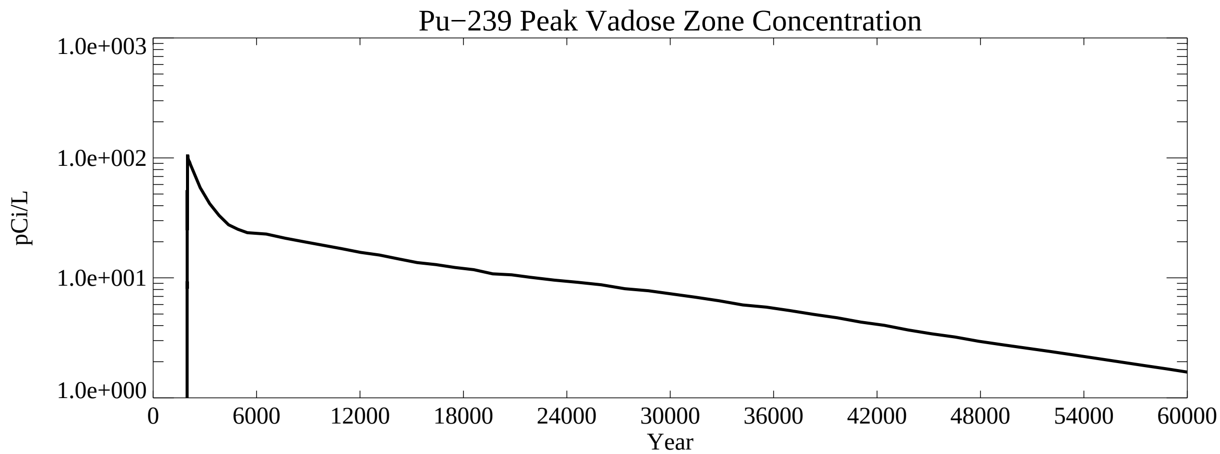

Figure A-9-22. Pu-239 peak vadose zone concentrations excluding tank farm submodel area (pCi/L).

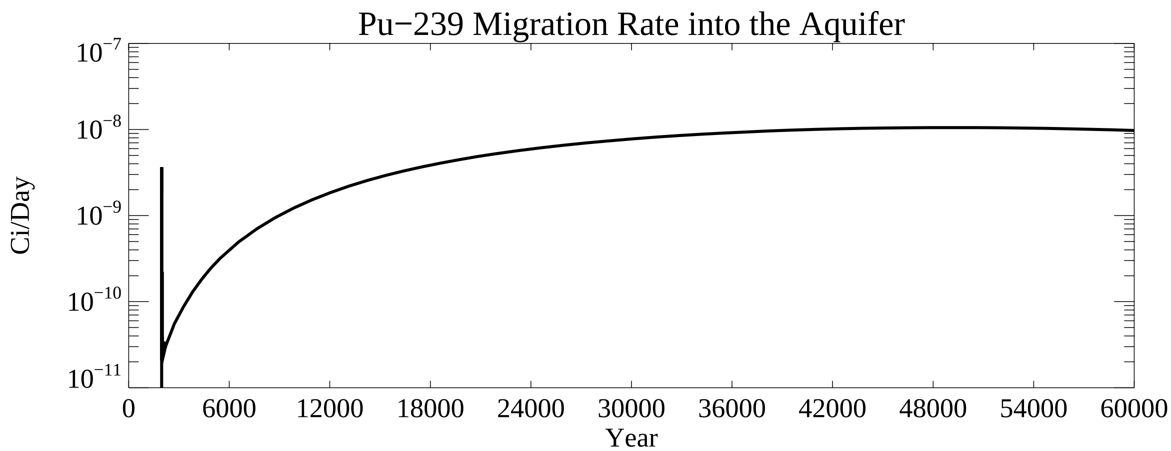

Figure A-9-23. Pu-239 activity flux into the aquifer (Ci/day).

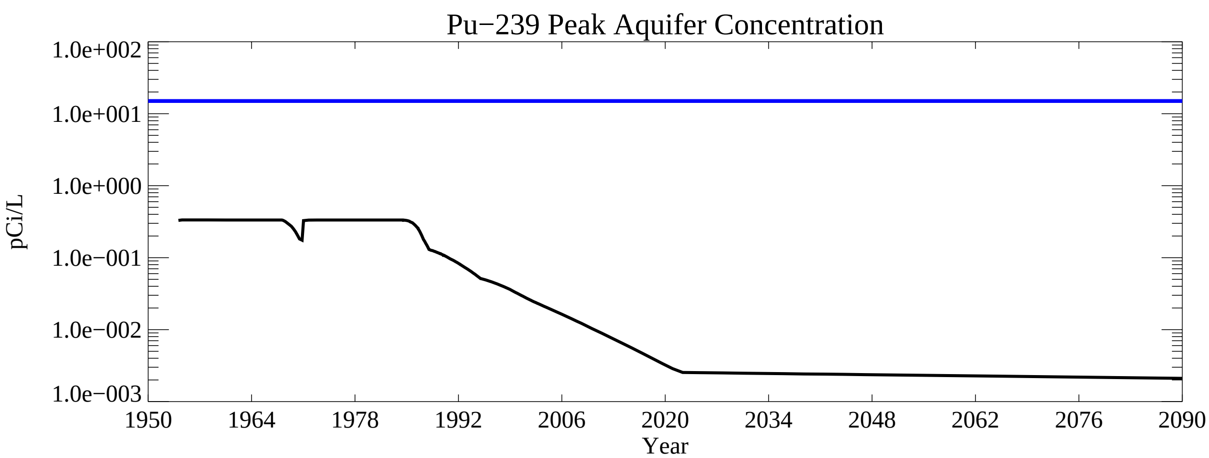

Figure A-9-24. Pu-239 peak aquifer concentrations (pCi/L) (SRPA MCL = blue line, model predicted = black line).

A-9.3.5 Pu-240

The sources of Pu-240 in the vadose zone, listed in order of decreasing magnitude, are (1) the tank farm sources at 1.07 Ci, (2) the OU 3-13 soil sites at 0.12 Ci, (3) CPP-3 injection well failure at 0.0005 Ci, and (4) the former percolation ponds at 0.0006 Ci. The amount of Pu-240 released directly into the aquifer from the injection well was 0.0063 Ci.

A-9.3.5.1 Vadose Zone Pu-240 Simulation Results

Figures A-9-25 and A-9-26 illustrate the horizontal and vertical distribution of the vadose zone Pu-240 at four time periods: 1979, 2005, 2049, and 2095. Figure A-9-27 presents the peak vadose zone concentrations through time. The tank farm sources (e.g., primarily CPP-31) account for most of the Pu-240. The alluvium and interbed retardation factors result in nearly all of the Pu-240 remaining in the alluvium with little Pu-240 transported to the aquifer. The peak vadose zone Pu-240 concentration (excluding the submodel area) was predicted to be 19.4 pCi/L in 1990. The large K_d allows the Pu-240 to behave as a continuous leaching source.

A-9.3.5.2 Aquifer Pu-240 Simulation Results

Like the Pu-239 simulation, the Pu-240 aquifer model was only run to evaluate the effect of the injection well Pu-240 on aquifer water quality. Figures A-9-27 and A-9-28 indicate that the peak vadose zone concentrations will fall below the Snake River Plain Aquifer MCL before the peak Pu-240 arrives in the aquifer. The Tc-99 and Sr-90 simulations indicate an activity flux to the aquifer resulting from the tank farm sources of nearly 10^{-5} Ci/day is needed to bring aquifer concentrations near 10 pCi/L. The peak Pu-240 activity flux is always less than 10^{-10} Ci/day after the failed injection well flux. The peak simulated aquifer Pu-240 concentration was 0.167 pCi/L in 1960 and is the result of the CPP-3 injection well. Concentration contour plots and concentration time history plots are not provided because the Pu-240 concentrations were always much less than the Snake River Plain Aquifer MCL of 15 pCi/L. Figure A-9-29 presents the peak aquifer concentrations resulting from the CPP-3 injection well through time averaged over a 15-m well screen.

The simulated Pu-240 in the aquifer is the result of direct injection to the CPP-3 well. The plutonium K_d (1,000 mL/g) and radioactive decay prevents significant transport of Pu-240 to the aquifer.

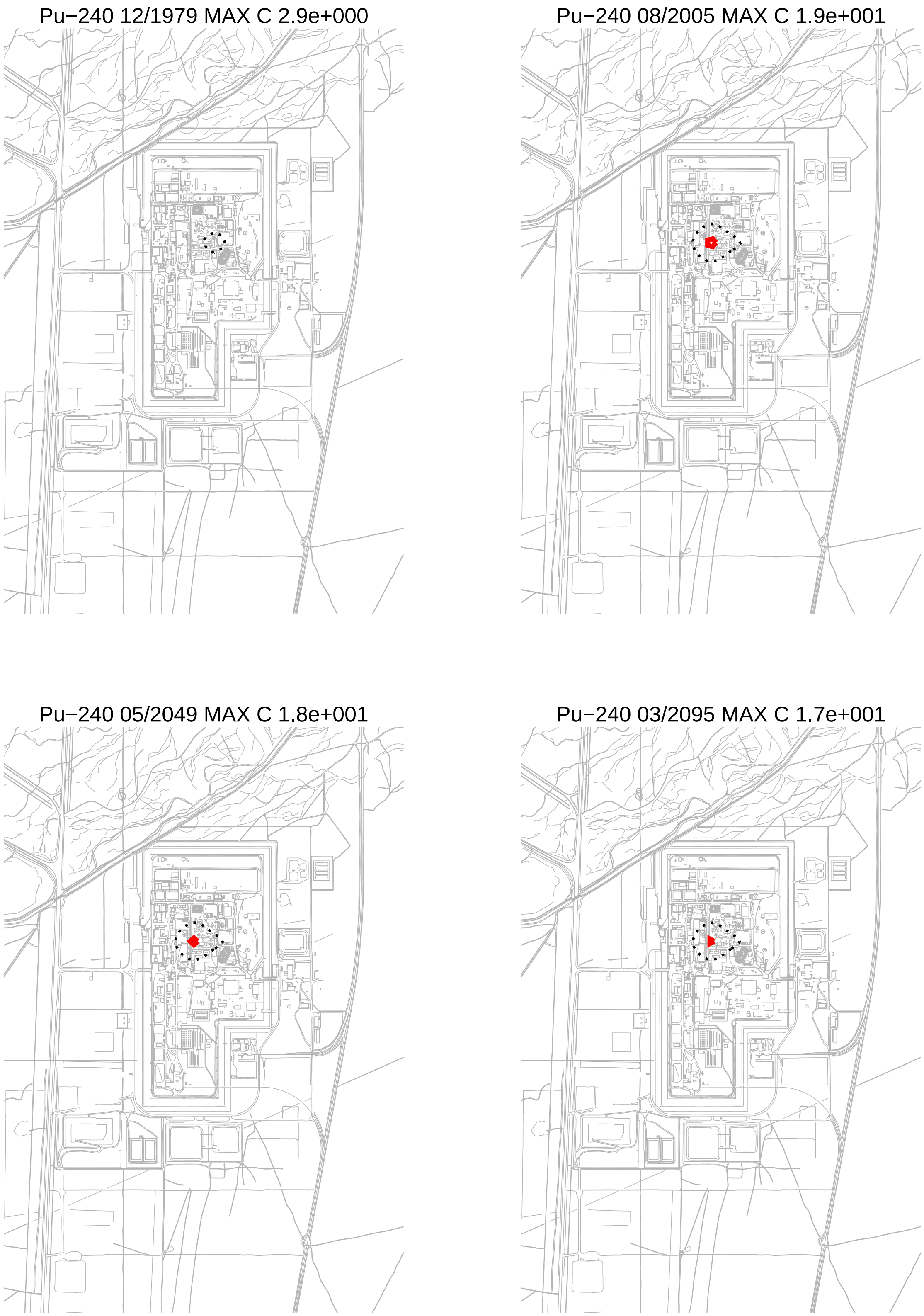

Figure A-9-25. Pu-240 horizontal vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

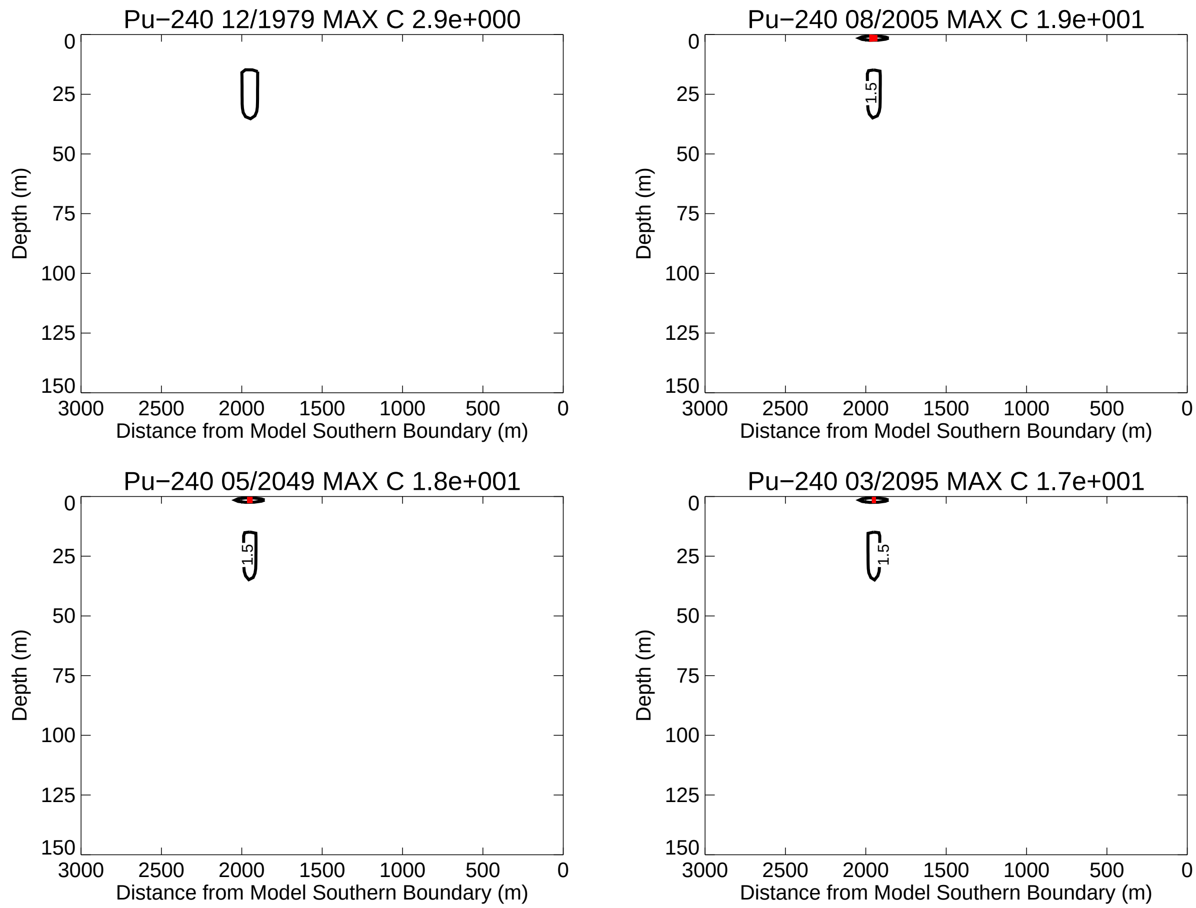

Figure A-9-26. Pu-240 vertical vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

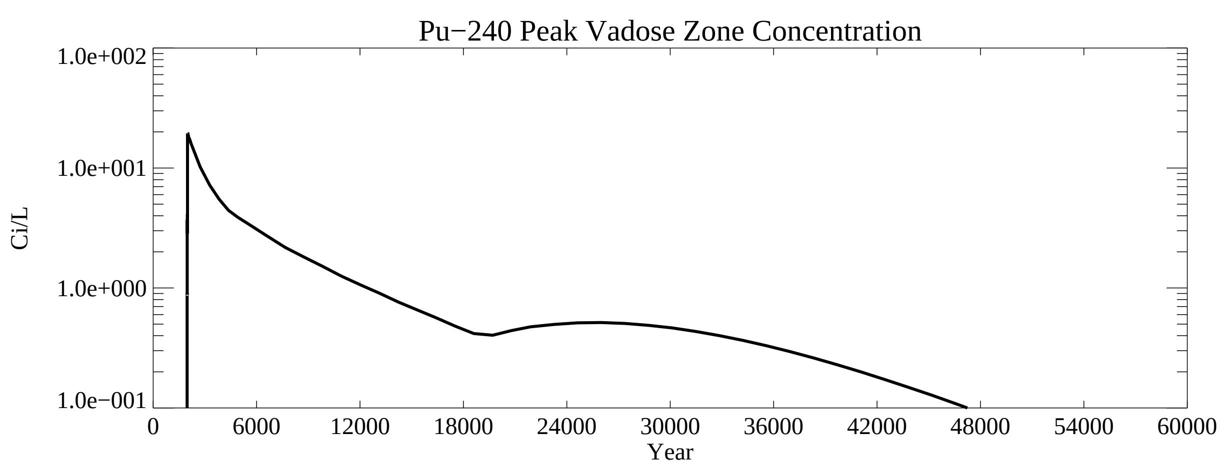

Figure A-9-27. Pu-240 peak vadose zone concentrations excluding tank farm submodel area (pCi/L).

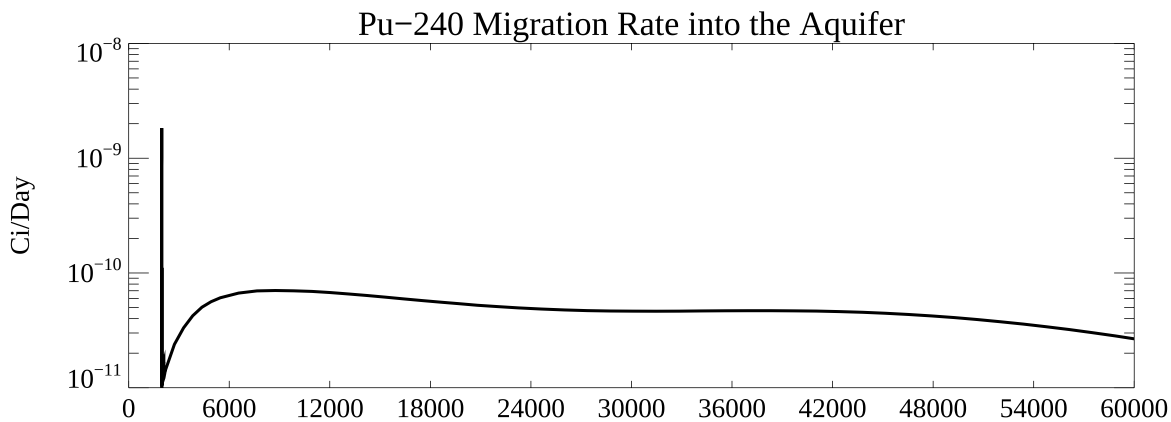

Figure A-9-28. Pu-240 activity flux into the aquifer (Ci/day).

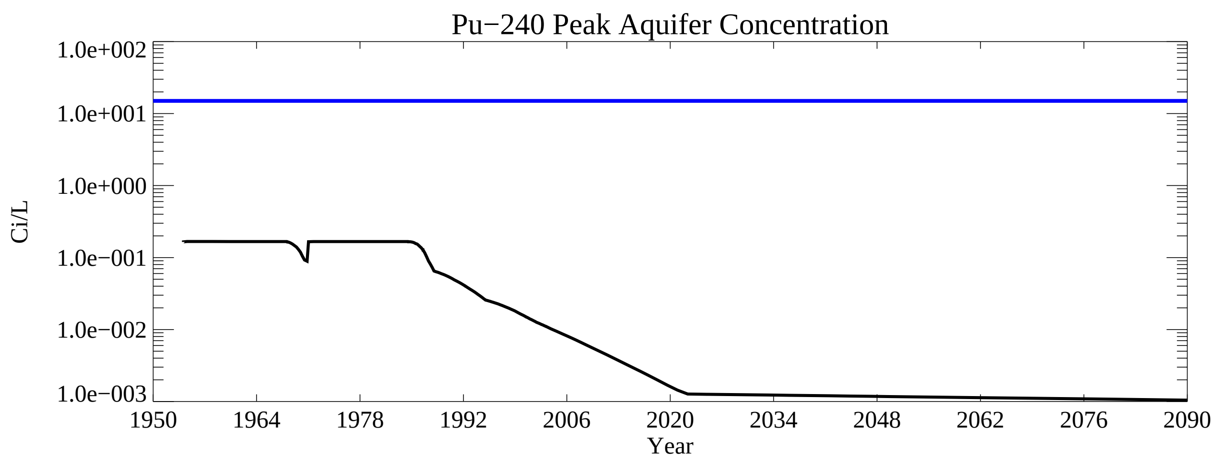

Figure A-9-29. Pu-240 peak aquifer concentrations (pCi/L) (SRPA MCL = blue line, model predicted = black line).

A-9.3.6 Tc-99

The sources of Tc-99 in the vadose zone, listed in order of decreasing magnitude, are (1) the tank farm at 3.56 Ci, (2) service waste ponds at 1.13 Ci, (3) CPP-3 injection well failure at 1.04 Ci, and (4) the OU 3-13 Group 4 soil sources at 0.1 Ci. The amount of Tc-99 released directly into the aquifer during the injection well failure was 10.9 Ci. Tc-99 is primarily produced as a fission product in nuclear fuel, and the naturally occurring background concentration should be zero. Tc-99 is long-lived and very mobile in the subsurface.

A-9.3.6.1 Vadose Zone Tc-99 Simulation Results

Figures A-9-30 and A-9-31 illustrate the horizontal and vertical distribution of Tc-99 in the vadose zone at four time periods: 1979, 2005, 2049, and 2095. The shallow vadose zone contamination located immediately northwest of the former percolation ponds is due to the CPP-22 OU 3-13 soil site (0.1 Ci), which was placed in the model in 1990. The CPP-22 site is a particulate air release south of CPP-603. Figure A-9-32 presents the peak vadose zone concentrations through time and Figure A-9-33 illustrates the Tc-99 peak activity flux into the aquifer.

Tc-99 from the tank farm releases has migrated deep into the vadose zone and has contaminated the aquifer beneath INTEC. The vast majority of the Tc-99 is from the tank farm sources in northern INTEC. However, the CPP-22 soil site located south of the CPP-603 building released 0.089 Ci, and high concentrations persist at this location because the infiltration rate is lower. The site straddles the southern INTEC fence line where the infiltration rate was 1 cm/year (outside the fence line). The Site CPP-22 source term was very conservatively overestimated and does not represent a realistic value for this site. The Site CPP-22 is a particulate air release south of Building CPP-603. The site covers a large area (13,900 m^2) and the soil contamination was assumed to be uniform across this area to a depth of 1.2 m at the maximum concentration measured.

The simulated Big Lost River had a large impact on Tc-99 peak activity flux into the aquifer. High recharge from high river flow in the simulations quickly drives Tc-99 residing in the deep vadose zone (i.e., 380-ft interbed) into the aquifer. The river recharge was estimated from losses during the period 1985-2004. The peak activity flux into the aquifer through time in Figure A-9-33 reflects the effect of the river. A hydrologic drought during the early 1990s resulted in reduced recharge and Tc-99 flux into the aquifer. The peak flow year for the Big Lost River recorded at Lincoln Boulevard bridge gauge was 1999 and this period is followed by the peak in Tc-99 concentration.

The peak simulated vadose zone Tc-99 concentration (excluding the tank farm submodel area) was 1.64e+5 pCi/L following the CPP-31 release.

A-9.3.6.2 Aquifer Tc-99 Simulation Results

Figure A-9-34 illustrates the horizontal distribution of aquifer Tc-99 at four time periods: 1979, 2005, 2049, and 2095. Figure A-9-35 presents the peak aquifer concentrations through time.

The peak simulated aquifer Tc-99 concentration was 935 pCi/L in 1999 and is the result of the tank farm Tc-99 residing deep in the vadose zone being quickly moved to the aquifer by the peak 1999 Big Lost River flow. The migration of Tc-99 through the vadose zone was greatly influenced by the simulated Big Lost River flows, and the highest Tc-99 concentrations in the aquifer from the tank farm releases occur immediately after the peak flow of the Big Lost River recorded at Lincoln Boulevard bridge gauge in 1999. The simulated concentrations declined following this peak flow primarily because a hydrologic drought began in 2000. However, simulated concentrations increased after 2005 because the model used the long-term average river flow after this date.

Currently, measured aquifer concentrations exceed the Snake River Plain Aquifer MCL in ICPP-MON-A-230 and aquifer well ICPP-2021. The concentration in Well ICPP-MON-A-230 are approximately an order of magnitude higher than the simulated highest aquifer concentrations. The recently drilled ICPP-2020 and -2021 wells confirm the ICPP-MON-A-230 well is not an anomaly, and a large area of the aquifer beneath INTEC is currently above the Snake River Plain Aquifer MCL. This suggests the vadose zone model may be overestimating vadose zone attenuation or underestimating the vadose zone Tc-99 sources.

The Tc-99 source term for Site CPP-31 has a greater uncertainty than the other radionuclides because the concentration was not measured during tank sampling but was estimated based upon fission yield. The accuracy of the Tc-99 inventory is likely only within a factor of two. Doubling the Tc-99 Site CPP-31 inventory would place the maximum simulated aquifer concentration (1999) near that currently measured in the aquifer. The simulated peak aquifer concentration in 2095 was approximately 10 pCi/L. This represents a factor of 100 decrease in concentration from simulated peak values. If the model trend is correct, concentrations should be nearly a factor of 10 below the Snake River Plain Aquifer MCL even if the inventory is increased by a factor of 10.

Figure A-9-30. Tc-99 horizontal vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

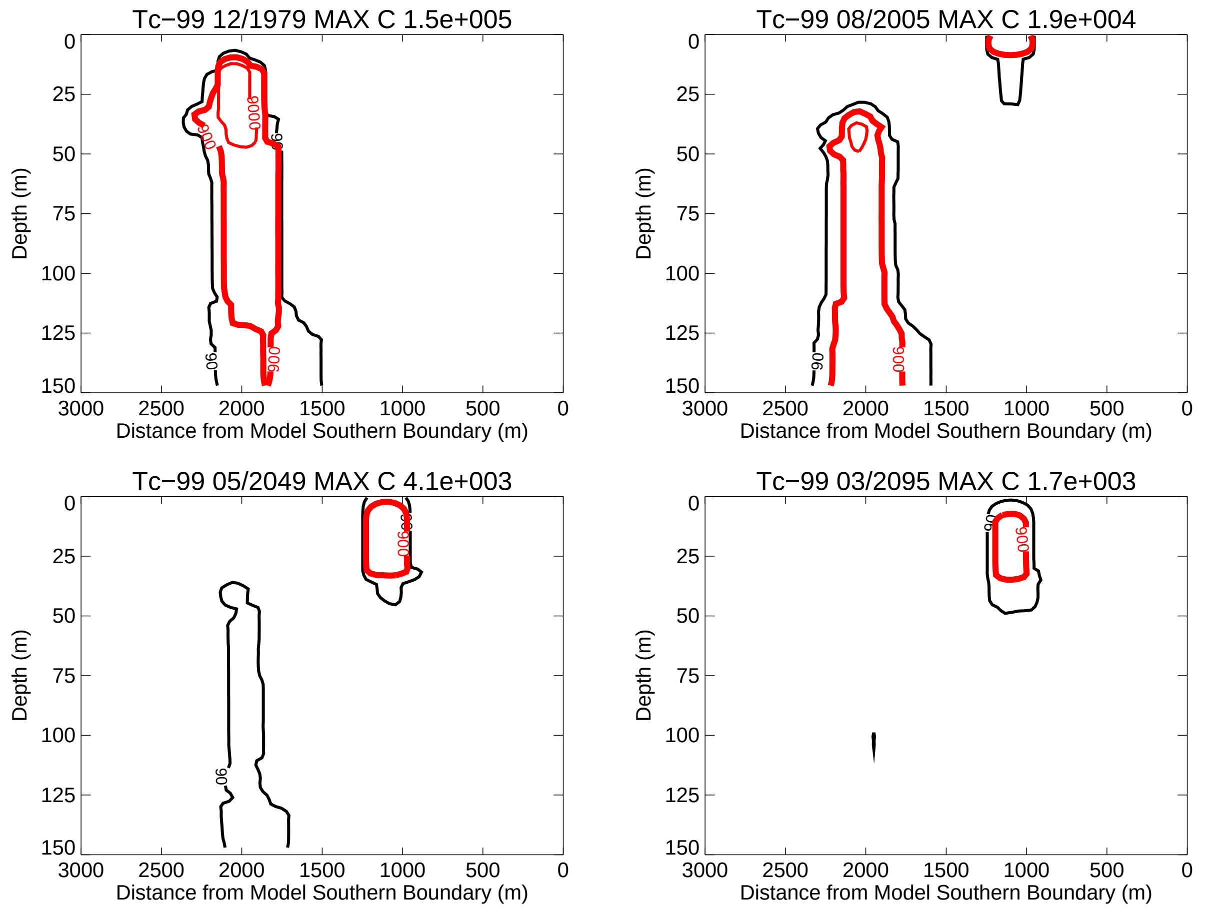

Figure A-9-31. Tc-99 vertical vadose zone concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line).

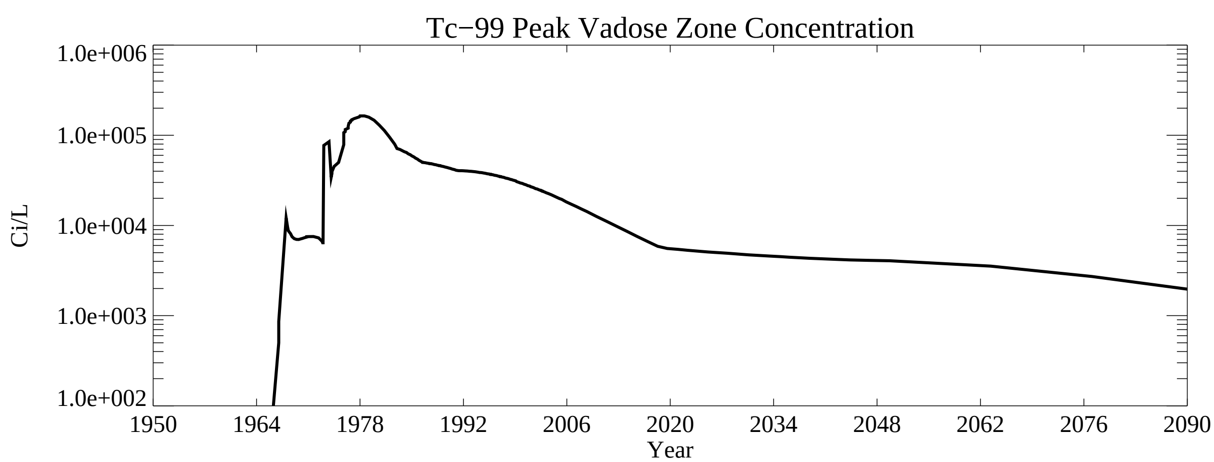

Figure A-9-32. Tc-99 peak vadose zone concentrations excluding tank farm submodel area (pCi/L).

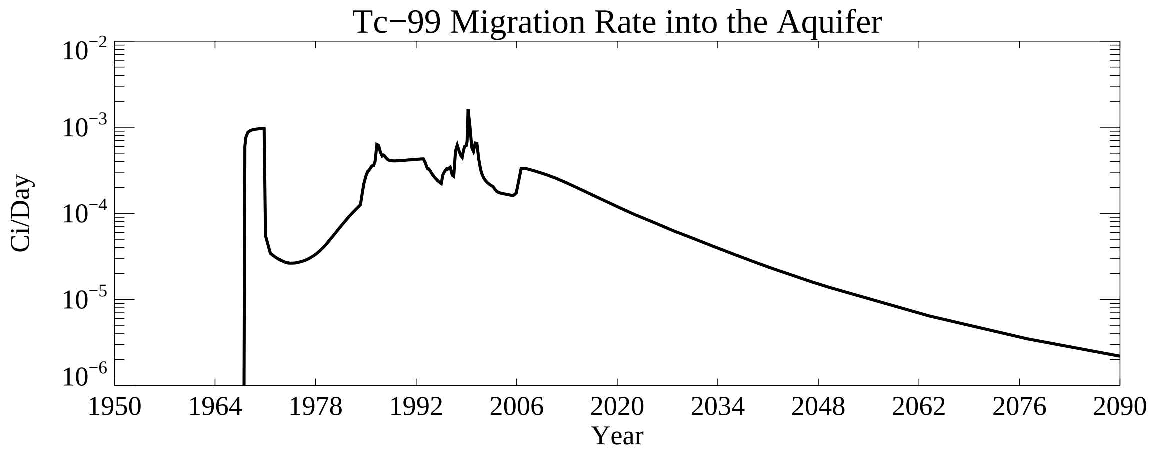

Figure A-9-33. Tc-99 activity flux into the aquifer (Ci/day).

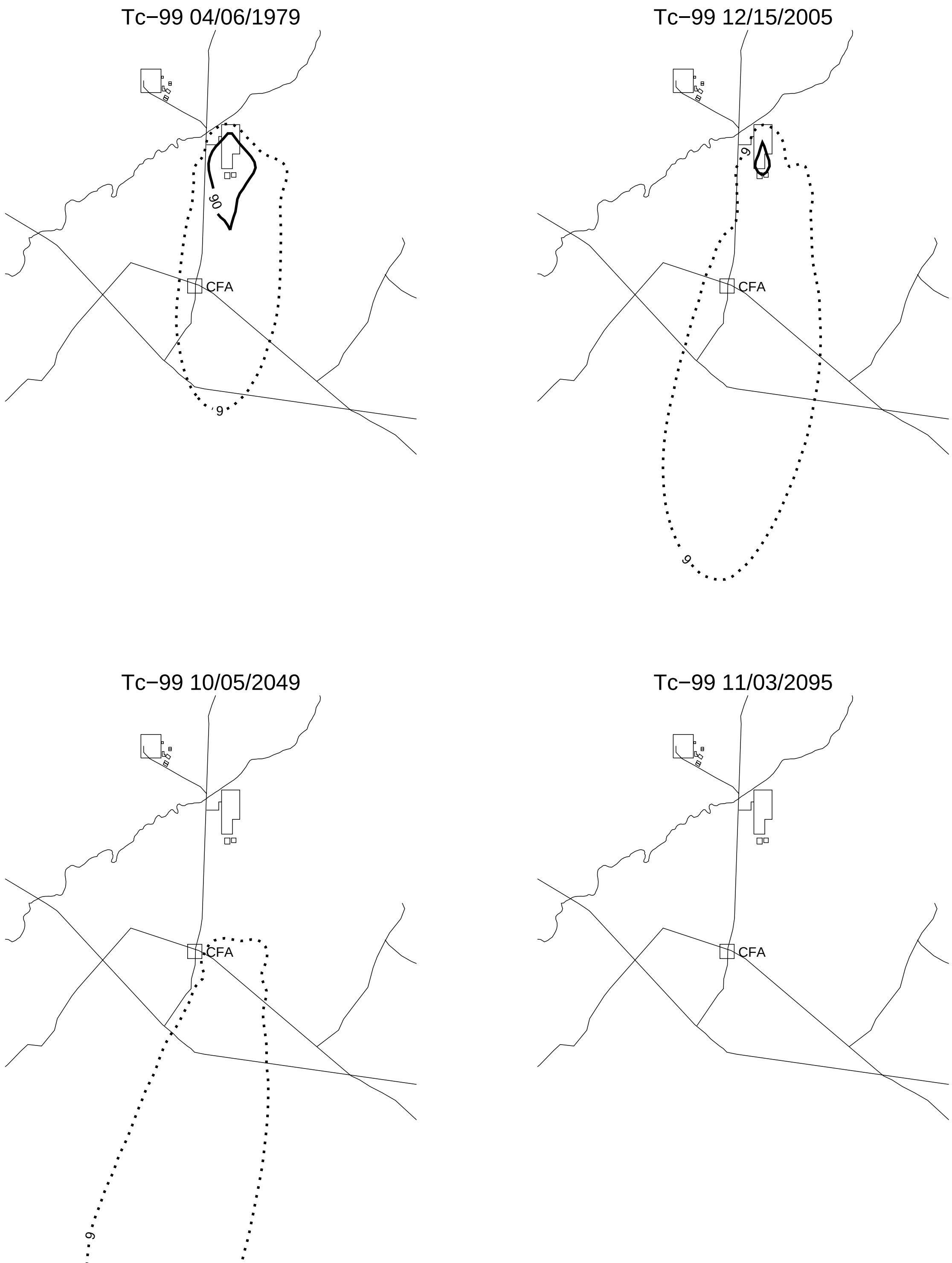

Figure A-9-34. Tc-99 horizontal aquifer concentrations (pCi/L) (SRPA MCL = thick red line, 10*SRPA MCL = thin red line, SRPA MCL/10 = thin black line, SRPA MCL/100 = thin black dashed line).